

NAVAL HEALTH RESEARCH CENTER

SLEEP DURING SEAL DELIVERY VEHICLE (SDV)/DRY DOCK SHELTER EXERCISES ANALYZED BY A GRAPHIC APPROACH

*P. Naitoh
T. L. Kelly
P. Hunt
H. W. Goforth, Jr.*

DTIC
ELECTE
FEB 17 1995
S G D

19950208 068

Report No. 94-30

Approved for public release: distribution unlimited.



NAVAL HEALTH RESEARCH CENTER
P. O. BOX 85122
SAN DIEGO, CALIFORNIA 92186 - 5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND



**Sleep During SEAL Delivery Vehicle (SDV)/Dry Dock Shelter
Exercises Analyzed by a Graphic Approach**

P. Naitoh, T. L. Kelly, P. Hunt, and H. W. Goforth, Jr.

Naval Health Research Center
P.O.Box 85122
San Diego, CA 92186-5122

Accession For	
NTIS CRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification _____	
By _____	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

Report No. 94-30, supported by the Naval Medical Research and Development Command, Department of the Navy, under work unit 61153N MR04101.003-6410 and 62233N MM33P30.02-6005. The views expressed in this article are those of the authors and do not reflect the Official Policy or position of the Department of the Navy, the Department of Defense, or the U.S. Government. Approved for public release; distribution is unlimited.

DTIC QUALITY INSPECTED 4

SUMMARY

Problem

Naval Special Warfare (NSW) personnel frequently participate in missions involving extended work hours and night work. These factors tend to have a negative effect on sleep patterns, which in turn could degrade cognitive performance.

Objective

This report has two purposes: 1) to make available to military planners a graphic approach for analysis of sleep survey data, and 2) to use this technique to evaluate two SEAL Delivery Vehicle (SDV)/Dry Dock Shelter (DDS) training exercises to determine whether these exercises disrupted sleep sufficiently to put safety or mission effectiveness at risk.

Approach

Sleep/wake patterns of NSW personnel participating in two SDV/DDS training exercises aboard a submarine were documented using sleep logs. These data were compared with the "normal" sleep pattern during shore duty based on sleep questionnaires.

Results

The sleep questionnaire data indicated that the participants in Exercise 1 (N=17) and Exercise 2 (N=18) had similar habitual sleep while on shore duty. During Exercise 1, sleep logs demonstrated no "sleep debt" or major sleep problems. However, the data did show (1) short sleep episodes, (2) short intersleep intervals, and (3) increased work scheduled during the 0300-0600 time period, compared to shore duty. During Exercise 2, sleep logs demonstrated a significant sleep debt and increased fatigue. Total sleep time was decreased and sleep was fragmented. Sleep was shifted, with morning sleep replacing the more refreshing nocturnal sleep period, and the work period extended from the afternoon to 0800.

Conclusion

Results from Exercise 1 suggest that missions with schedules similar to this exercise allow adequate sleep to maintain cognitive performance. However, if the fragmented sleep schedule persisted for a very extended time (i.e., more than 4 weeks) it could impair alertness. Results from Exercise 2 suggest that deterioration of cognitive performance could be a risk because of long hours of work, nighttime work periods, and accumulation of a sleep debt. Possible interventions to support mission accomplishment include: more careful sleep management to allocate greater amounts of time for personnel to sleep, a complete shift to a "night shift" work schedule at least a week ahead of the operation to increase nighttime alertness and improve daytime sleep, and pharmacological or nonpharmacological agents to improve sleep and/or alertness. Other special operations units may benefit from similar sleep surveys. The graphic technique is a simple and effective method for evaluating sleep logs and sleep questionnaires.

INTRODUCTION

Naval Special Warfare (NSW) personnel frequently participate in missions involving extended work hours and nocturnal waking periods. This can have a negative effect on sleep patterns, which in turn could have detrimental impact on cognitive performance. Environmental factors aboard submarines that degrade quantity and quality of sleep and increase fatigue of NSW Sea-Air-Land (SEAL) personnel have been previously evaluated by Phil Hunt, CDR, MC, USN, a submarine medical officer (unpublished memorandum). Such factors include (1) persistent light, noise, crowding and activity in the berthing area, and (2) conflicts between the work/rest schedules of the submarine crew and SEAL Delivery Vehicle (SDV)/Dry Deck Shelter (DDS) personnel. Hunt recommended that the berthing area be made more conducive to quality sleep. He also recommended regular use of an aerobic exercise machine which, in addition to physiological benefits, may improve quality and quantity of sleep.

Sleep surveys are an important tool to assist in the development of an appropriate work/rest schedule for a given mission scenario. These techniques have been used previously in relation to many different occupations, both in the military and the civilian sectors (e.g., *Investigation of the Navy Workweek at Sea*, 1975, by the Navy Personnel Research and Development Center, San Diego, and *The Standard ShiftWork Index*, 1991, by the Shiftwork Research Team at the University of Sheffield, England). A guide to optimizing sleep during special warfare operations has been published (Naitoh & Kelly, 1992); however, the sleep log/sleep questionnaire analysis techniques necessary to assess wake/sleep patterns were not explained in that report. The present publication seeks to make these tools available to military planners involved in preparing operational schedules, and to individual SEALs who have experienced sleep management problems. A graphic technique for analysis of sleep surveys is presented using data from two surveys of SEAL sleep patterns during SDV/DDS operational exercises to determine whether sleep was disrupted sufficiently to decrease personnel mission effectiveness.

MATERIALS AND METHODS

Sleep surveys, including a baseline sleep questionnaire (Appendix A) were administered prior to the start of the operation and daily sleep logs (Appendix B), kept during the mission exercise, were collected from volunteers participating in each of two SDV/DDS exercises. Information regarding sleep timing, total sleep duration, and sleep latency (time to fall asleep) during normal weekdays on shore duty was obtained from the sleep questionnaire. Sleep timing, duration, and sleep latency during the exercise were estimated from the sleep logs. (Sleep log data were not available for the shore duty period; however, because the sleep/wake schedule on shore is relatively stable, a sleep questionnaire provides adequate information.) The details of operational scenarios, such as frequency, duration, and time of each SDV excursion during the exercises, have been excluded from this study to keep this document unclassified and available to all those interested in learning basic sleep management analyses. However, it should be noted that this lack of operational detail limits the recommendations that are presented in this report.

The first exercise (Exercise 1) lasted 7 days (December 4-10, 1990). The 17 participants completed 1-7 consecutive sleep log cards per subject during the mission, for a total of 86 cards. The average age was 29.8 ± 5.9 years (range 22-40 years). Twenty-one volunteers participated in the second exercise (Exercise 2) for a period of 8 days (October 14-21, 1991). Of these volunteers, 15 completed sleep log cards for 8 consecutive days and 3 others completed the cards for 7 consecutive days, for a total of 141 sleep log cards. The average age of participants in Exercise 2 was 25.7 ± 3.3 years old (range 21-33 years). All participants from both exercises completed a baseline sleep questionnaire.

Analysis:

Procedures recommended for sleep log analysis (Naitoh, Banta, Kelly, Bower & Burr 1990) are summarized in Appendix C. Sleep logs completed by SEALs in both Exercise 1 and 2 were analyzed to produce: (1) sleep fraction (the percent of personnel asleep during each half hour interval of the day); (2) sleep episode (the duration of uninterrupted hours of sleep); (3) intersleep interval (the number of hours between sleep episodes); and (4) hours of work in the last 24. The differences in sleep measures between Exercise 1 and 2, and the changes within the groups, were evaluated by symmetry and zero- μ t tests, using SYSTAT computer software. One

subject in Exercise 1 was excluded from the analyses because his data was questionable (sleep logs indicated 15 hours a day of sleep).

RESULTS

Weekday sleep, when subjects in Exercise 1 were on shore duty, was 7.0 ± 1.0 hours (range 5-8 hours), and sleep latency was 16.3 ± 15.4 minutes (range 2.5-60 minutes). Weekday sleep while on shore duty for those in Exercise 2 was 6.9 ± 1.1 hours (range 5-8.5 hours), and sleep latency was 13.9 ± 7.4 minutes (range 5-30 minutes). Table 1 presents sleep characteristics extracted from sleep logs collected during the two exercises.

Table 1. Sleep Characteristics of SEALs in Exercise 1 and Exercise 2

Variable Name	Scoring Weights/Measurement Unit	Mean \pm SD (range)	
		Exercise 1	Exercise 2
Trouble going to sleep	1=none; 2=light; 3=moderate; 4=considerable	1.9 \pm 1.0	1.8 \pm 0.7
Time to fall asleep	minutes	19.4 \pm 17.0	16.6 \pm 16.0
Awakening from sleep	number of awakenings	1.6 \pm 1.4	1.3 \pm 1.0
How well rested	1=well rested; 2=moderate; 3=slight; 4=not at all	2.2 \pm 0.8	2.5 \pm 0.5
Need more sleep	1 = yes; 2 = no	1.4 \pm 4.9	1.3 \pm 0.3
Today's mood	1=very poor; 2=poor; 3=average; 4=good	3.3 \pm 0.6	2.9 \pm 0.5
Hours of work (in last 24)	hours	7.2 \pm 5.5 (1.0-21.0)	13.2 \pm 3.6 (7.9-20.8)
Total sleep time	hours	7.5 \pm 1.4 (4.8-10.3)	6.1 \pm 1.2 (3.1-8.9)
Intersleep intervals	hours	11.7 \pm 7.2 (1.0-29.0)	16.9 \pm 4.2 (11.0-28.6)
Sleep episode	hours	5.3 \pm 2.6 (0.5-11.5)	4.7 \pm 1.0 (2.6-6.5)

Sleep/wake patterns documented by the sleep logs are diagrammed in Figure 1 for Exercise 1, and in Figure 2 for Exercise 2. Each horizontal line represents time spent sleeping, as indicated on a sleep log card. In Figure 2 the sleep/wake pattern is plotted separately for each day of the exercise; however, the number of sleep log cards obtained in Exercise 1 were too few to use this format. Instead, all sleep log cards were plotted on a 1-day x-axis in Figure 1, with the day arbitrarily defined from 1800 to 1800. The Y-axis in Figure 1 shows the identification

(ID) numbers of the sleep log cards. The Y-axis in Figure 2 indicates the ID numbers of the subjects. In Figure 2, the shaded areas mark the 2200-0600 time period each day when the participants normally slept when they were on shore duty. During days 2, 4, and 6 of Exercise 2, most participants were awake and working during their normal sleep period of 2200-0600, and slept in the mornings. Day 6 is particularly deviant from the normal work/rest schedule in that the participants not only worked for long hours during night and early morning hours, but their recovery sleep the following morning was very short.

Sleep fraction for each half hour period across the 24 hour cycle is plotted in Figure 3 for Exercise 1, and Figure 4 for Exercise 2. In Exercise 1, 20-30% of the participants were awake from 0300 to 0600. In Exercise 2, 40-50% of the subjects were awake during this time period, indicating a major shift in the work schedule to early morning hours. Participants in Exercise 1 had intersleep intervals of 11.7 ± 7.2 hours and uninterrupted sleep episodes of 5.4 ± 2.8 hours. Those in Exercise 2 had intersleep intervals of 16.9 ± 4.2 hours and uninterrupted sleep episodes of 4.7 ± 1.0 hours. Examples of graphic displays of these two measures are shown in Figures 5 (intersleep interval) and 6 (uninterrupted sleep episode), using data from Exercise 1.

Duration of sleep compared to habitual sleep is plotted in Figure 7 for Exercise 1 and in Figure 8 for Exercise 2. Sleep durations that fall in the shaded area represent accumulation of sleep debt. No sleep debt was accumulated during Exercise 1; however, most sleep durations during Exercise 2 were shorter than habitual sleep duration for those subjects. Figure 8 shows that the participants experienced serious sleep debt as a group, especially during the last 3 days of Exercise 2. Sleep duration during Exercise 2 was significantly shorter than the habitual sleep length [$t(17) = 2.39, p=0.03$], and participants in Exercise 2 got significantly less sleep per day than participants in Exercise 1 [$t(28)=3.06, p=0.005$]. Sleep latency did not change significantly, compared to sleep on shore, in either Exercise.

The fraction of subjects asleep during the 0300-0600 period, uninterrupted sleep episode duration, intersleep interval, and hours of work in the last 24 hours data for Exercises 1 and 2 are summarized in Table 2, along with comparison data from sailors on shore duty (no shiftwork), sailors aboard a ship stationed in the Gulf of Tonkin (Vietnam Study), and sailors on board ship in the Persian Gulf (Desert Storm Study).

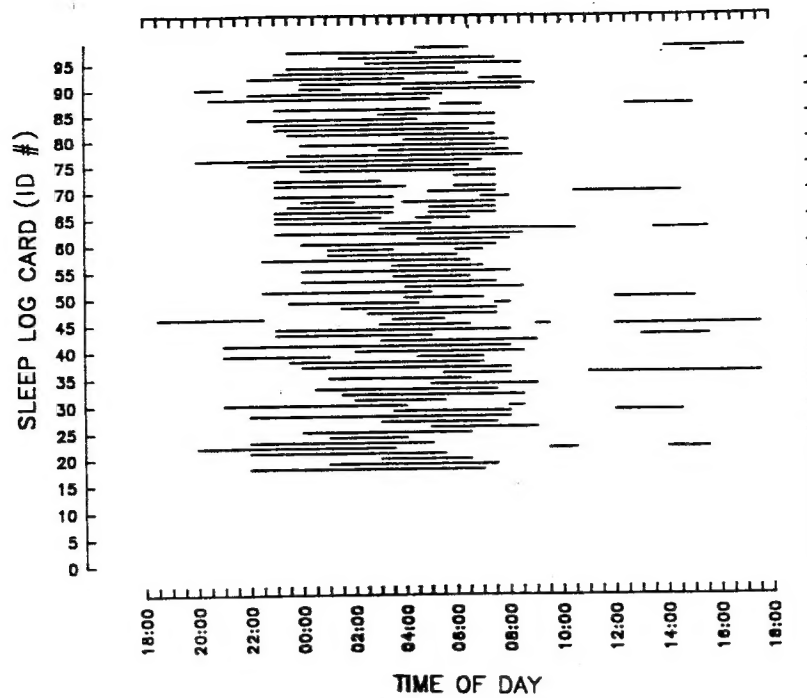


Figure 1: Sleep/Wake Patterns in Exercise 1. Each horizontal line represents a sleep period as indicated by a sleep log card. The Y-axis shows individual sleep card numbers. The X-axis shows time of day. For this exercise, data from all days have been combined.

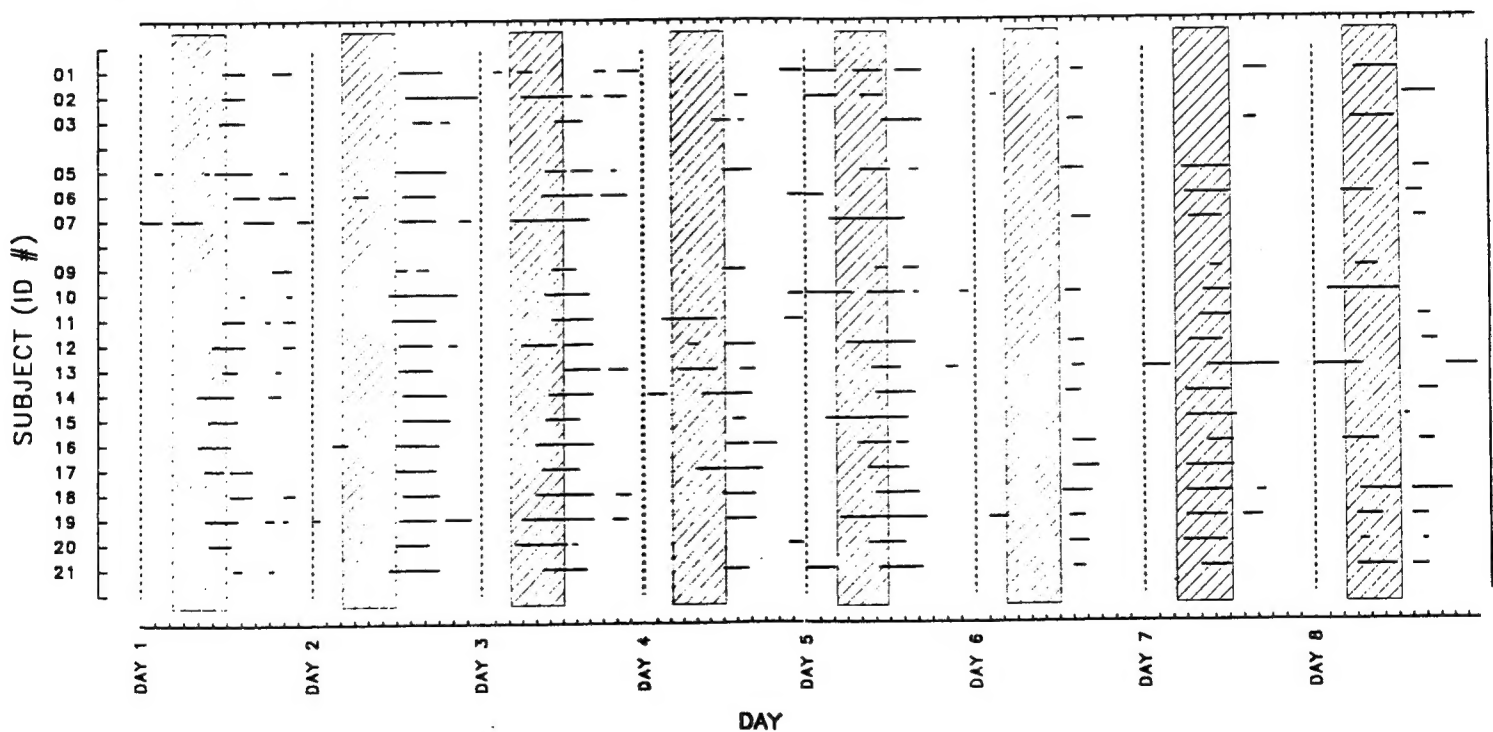


Figure 2: Sleep/Wake Patterns in Exercise 2. Each horizontal line represents a sleep period as indicated by a sleep log card. The Y-axis shows individual subject numbers. The X-axis shows the mission days. Shaded areas mark 2200-0600, the habitual sleep period on shore.

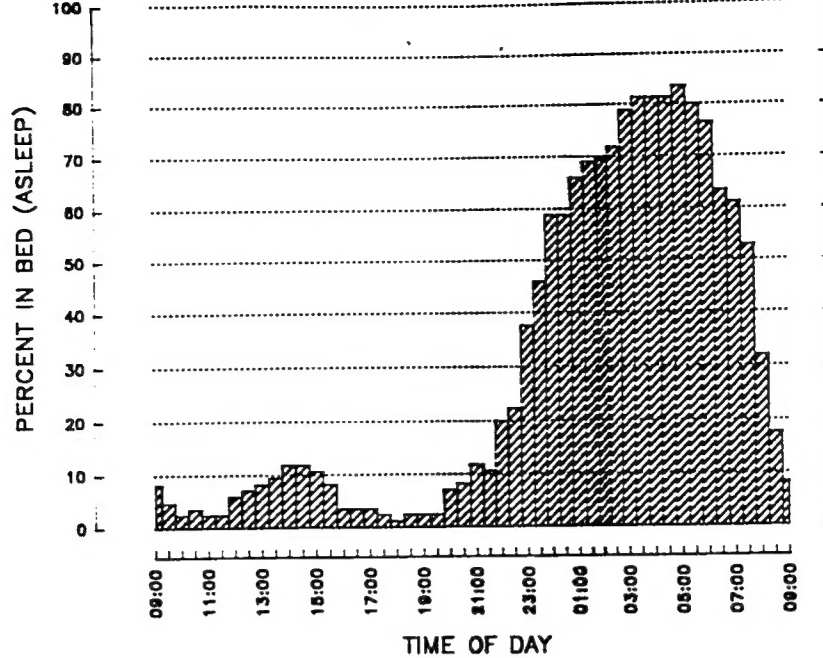


Figure 3: Sleep Fraction for Exercise 1: The X-axis shows time of day, and the Y-axis shows the percentage of participants asleep at a given time for Exercise 1. Note that 20-30% of participants were awake and "at work" during the 0300-0600 time period.

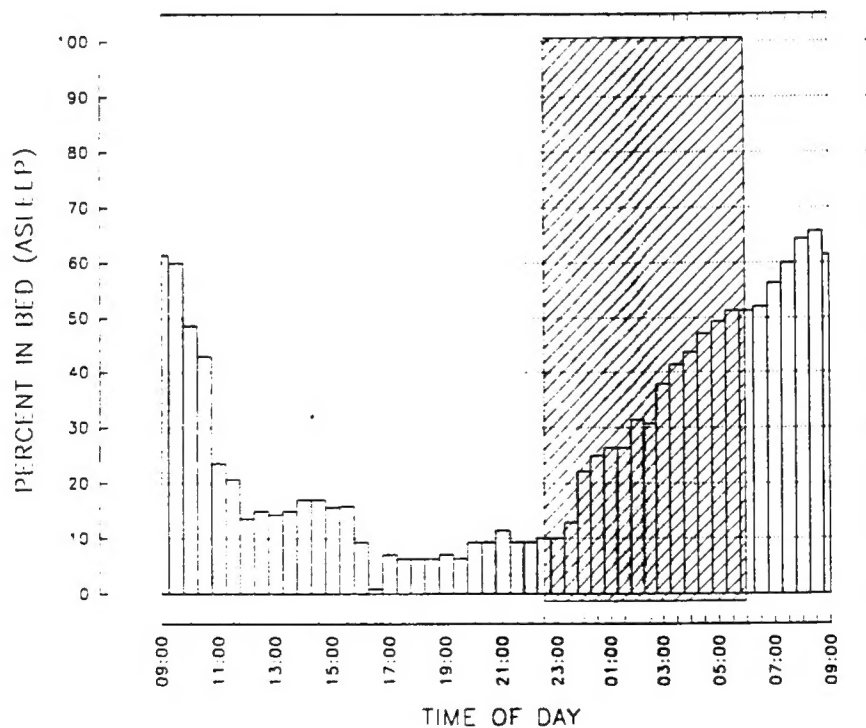


Figure 4: Sleep Fraction for Exercise 2: The X-axis shows time of day, and the Y-axis shows the percentage of participants asleep at a given time for Exercise 2. Note that 40-50% of participants were awake and "at work" during the 0300-0600 time period.

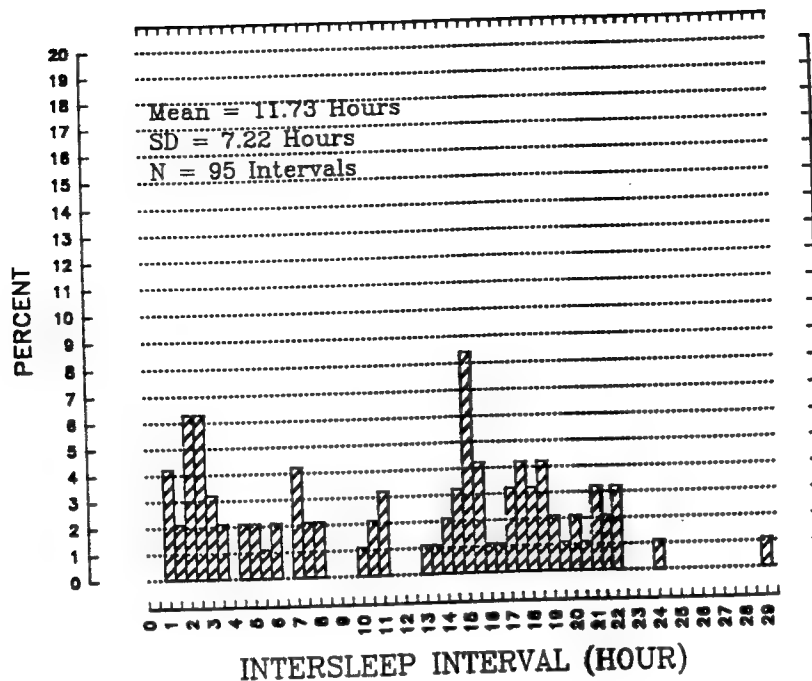


Figure 5: Intersleep Intervals during Exercise 1. The X-axis shows intersleep intervals, the elapsed time between the end of one sleep period and the start of the next sleep period, in hours. The Y-axis shows the percentage of intersleep intervals that were of a given duration.

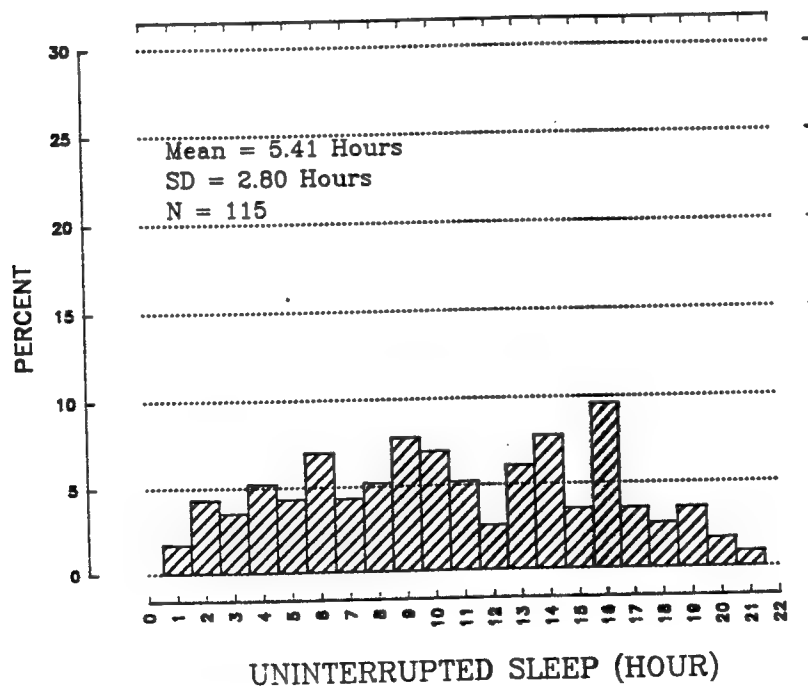


Figure 6: Sleep Episode during Exercise 1. The X-axis shows the duration of uninterrupted sleep intervals in hours. The Y-axis shows the percentage of sleep episodes that were of a given duration.

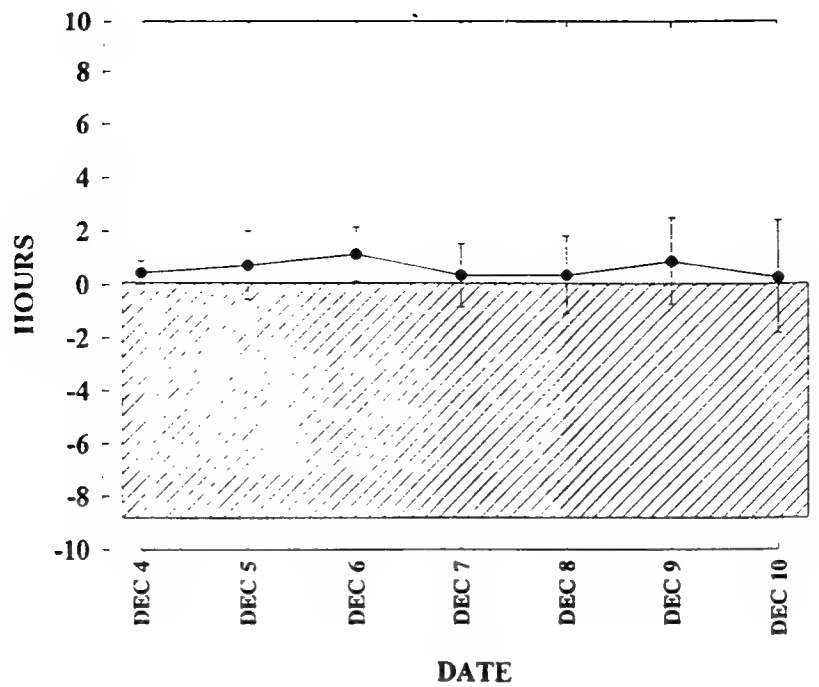


Figure 7: Sleep Debt during Exercise 1 for the 8 subjects with habitual sleep length data. The X-axis shows days of the exercise. The Y-axis shows difference in the mean hours of sleep each day from the habitual sleep duration. The shaded area indicates sleep debt.

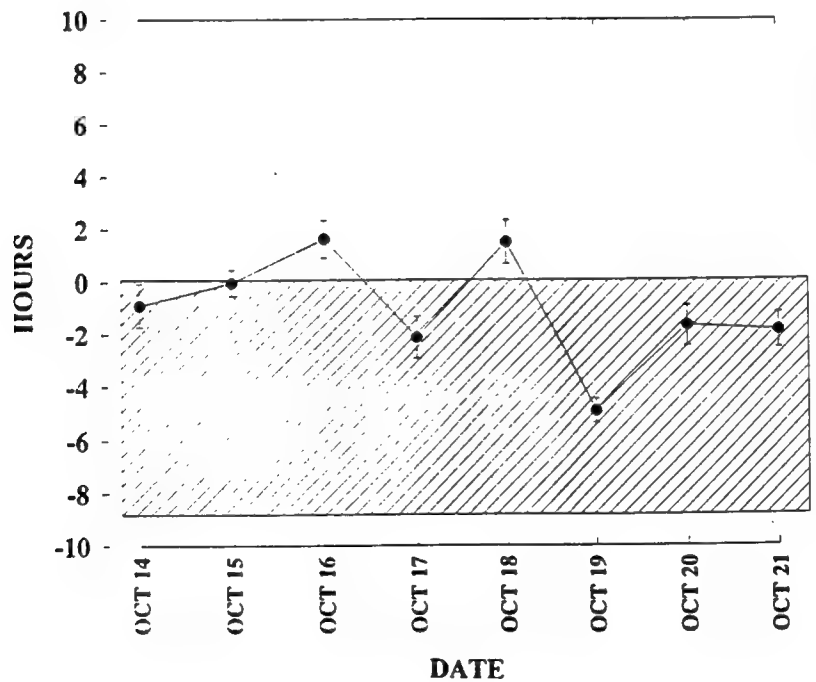


Figure 8: Sleep Debt during Exercise 2. The X-axis shows days of the exercise. The Y-axis shows difference in the mean amount of sleep obtained each day from the habitual sleep length. Points falling in the shaded area indicate sleep debt.

Table 2. Comparison of Sleep Measures of SEALs with Routine Shore Duty and Combatant Surface Fleet Personnel

Sleep Variable	Sleep Fraction	Uninterrupted Sleep Episode	Intersleep Interval	Hours of Work in Last 24
Shore Duty	5% < Awake	8 hrs	16 hrs	8 hrs
Surface Fleet (Vietnam Study)	20% Awake	1-11 hrs	1-27 hrs	N/A
Surface Fleet (Desert Storm)	10-30% Awake	6.6 hrs	13.9 hrs	N/A
SEALs (Exercise 1)	20-30% Awake	5.4 hrs	11.7 hrs	7.2 hrs
SEALs (Exercise 2)	40-50% Awake	4.7 hrs	16.9 hrs	13.2 hrs

N/A = Not Available

Details about the data sets on "Shore Duty" and "Surface Fleet (Vietnam Study)" are described in Naitoh (1982).

DISCUSSION

In studies requiring participants to recall events, the reliability of the survey tools must be critically reviewed. Mullington, Spielman, Wells, and Hoffman (1988), asked graduate students to complete sleep logs for 42 consecutive days. They found that 7 to 10 consecutive days of sleep log data provided sufficient stability. The average sleep time determined from 7 days of data exhibited a 0.85 correlation with that based on 42 days of data. Since only 9 of the 17 participants in Exercise 1 completed a full 7 days of sleep log cards, these data may not be sufficiently reliable to estimate the detailed sleep profile in Exercise 1. However, these data may be adequate to demonstrate general changes in sleep patterns during the mission. In Exercise 2, all subjects completed at least 7 days of sleep log cards and thus provide reliable sleep profile estimates.

The participants in Exercises 1 and 2 had similar sleep duration and latency while on shore duty. During Exercise 1, participants slept for an average of 7.5 hours. They did not

experience difficulty falling asleep in their berthing environments. In contrast, participants in Exercise 2 had an average sleep duration of 6.1 hours, 1 hour less than their shore duty sleep and significantly less than participants in Exercise 1.

Even though the average sleep duration of participants in Exercise 1 was not different from that of the baseline shore duty period, they did not exhibit normal sleep patterns during the exercise. Normally, the intersleep interval (defined as elapsed time between the end of one sleep period and the start of the next) is 16 hours, reflecting the fact that people usually sleep for about 8 hours once every 24 hours. The average intersleep interval during Exercise 1 (11.7 hours, Figure 5) was far shorter than 16 hours. Duration of individual sleep periods averaged 5.3 hours (Figure 6). Thus, participants in Exercise 1 had more than one sleep period per 24 hours. It is estimated that maximal recuperation is obtained with 7-8 hours of uninterrupted sleep per day (Naitoh, Englund, & Ryman, 1986). Decreasing sleep below this amount or breaking it into shorter segments can decrease recuperative effects. The intersleep interval for participants in Exercise 2 (16.9 ± 4.2 hours) was close to the normal 16 hours, but the sleep episode was short (4.7 ± 1.0 hours). Thus, the participants in Exercise 2 worked for longer periods before they were allowed to sleep for shorter periods than those in Exercise 1.

Table 2 compares Exercise 1, Exercise 2, and three other sleep surveys in terms of: (1) sleep fraction during the 0300-0600 period; (2) uninterrupted sleep duration; (3) intersleep interval; and (4) hours of work in the last 24. Sleep fraction, or percentage of a group of subjects asleep at a given time of day, is a technique developed by Lewis and Masterson, 1957, which provides an indication of whether a group is able to maintain a predominantly nocturnal sleep pattern on a given work schedule. In Exercise 1, 20-30% of the subjects were awake during the 0300-0600 period. Under a normal shore duty work schedule (top row of Table 2), less than 5% would be awake during that time period. The participants in Exercise 2 suffered an even greater shift in working hours, with 40-50% of the participants reporting being awake during the 0300-0600 time period and asleep in the morning. Graphic display of sleep fraction across the 24-hour period provides a detailed picture of the degree to which sleep has been shifted. Comparing Figures 3 and 4 shows that participants in Exercise 1 retained a predominantly nocturnal sleep pattern while participants in Exercise 2 had their sleep shifted into

the morning hours. A full discussion of sleep fraction, intersleep intervals, and uninterrupted sleep episode can be found in a chapter by Naitoh in a 1982 book, *Rhythmic Aspects of Behavior*.

Sleep debt is perhaps the most important sleep measure for evaluating a work/rest schedule. Decreasing sleep duration by a given amount over multiple days causes greater sleep deprivation effects than after a single day of reduced sleep. Generally, accumulation of sleep debt will be followed by one or more sleep periods of longer-than-habitual or equal-to-habitual sleep length (Nicholson & Stone, 1982). In contrast, participants in Exercise 1 accumulated no sleep debt over the 7 day exercise (Figure 7), and none of the participants in Exercise 1 reported working continuously for 24 hours or longer (skipping a sleep period altogether). Participants in Exercise 2 accumulated a significant sleep debt (Figure 8), and three volunteers in Exercise 2 worked continuously for more than 24 hours without sleep. Additionally, Exercise 2 participants had almost twice as many hours of work per 24 hour period as those in Exercise 1. There was a concomitant increase in the number of comments about fatigue from Exercise 2 participants noted in the remarks section of their sleep logs (Appendix B, item 11).

Although increased fatigue and sleep debt may be unavoidable consequences of some NSW missions, there are interventions that can improve operational safety and efficiency of participants. For example, if the daytime sleep of personnel working on night missions is being compromised by scheduling briefings and other activities for the convenience of other personnel working a daytime schedule, altering the time of such activities to protect an adequate daytime sleep period should be considered. If berthing conditions are poor, an effort should be made to improve them. If there is adequate advance preparation time available, the sleep/wake schedules of team members could be shifted from the daytime oriented pattern to the anticipated mission work schedule well before (at least a week before) the start of the exercise. If personnel living under the controlled light conditions of the submarine stayed rigorously on a night-shift schedule, then their internal circadian rhythms would synchronize to that schedule. This would allow them to sleep better during the day and to be more alert at night, improving operational safety and efficiency. Such a daytime to nighttime shift in the work schedule is logistically difficult and requires personal sacrifice, but it may be worth the effort on special high-risk missions.

Sedative-hypnotic drugs may be used to facilitate sleep under adverse conditions to prevent accumulation of a sleep debt prior to an operation. However, they should not be used

during an operation if there is a risk that the individual will be called upon to engage in critical activities while residual drug effects are still present. Additionally, using such drugs before an operation risks impairing sleep during the operation due to rebound insomnia. Melatonin, a natural substance related to the body's sleep wake cycle, is being studied as a possible sleep promoting agent with fewer side effects. Further testing is required to determine if it is an appropriate agent for use during NSW operations. Nonpharmacological techniques for improving sleep quality are also marketed (e.g., special audio tapes with which personnel can train themselves to sleep better under adverse conditions). Such techniques remain to be tested under NSW operational conditions.

Interventions to directly increase alertness also exist. Brief use of selected pharmacological stimulants may sometimes be indicated. Careful timing is necessary so that the stimulant that improves alertness during the work period does not subsequently impair sleep during the sleep period. Even commonly used doses of caffeine can impair sleep. Most prescription stimulants are contraindicated because of additional risks of abuse and negative side effects. Preliminary information on the new stimulant modafinil, suggests that it is as effective as amphetamines without the risk of abuse or negative side effects (unpublished data). Nonpharmacological interventions can also affect alertness. For example, there is evidence to suggest bright light has direct alerting effects. Bright light conditions are not feasible while diving or in an SDV. However, alertness of personnel performing mission related activities while aboard a submarine might be improved with bright light. Portable devices (e.g., light visors) are being developed which could make bright light exposure practical in the submarine environment. Appropriately timed bright light exposure can have the added benefit of synchronizing the circadian rhythm of alertness to the desired work schedule.

This study used a paper-and-pencil sleep survey. However, the analytical methods described in this report are labor-intensive, because the sleep log data must be manually transcribed before it can be processed by computer programs. With a moderate increase in cost, similar data could be collected and processed more easily using either a fax-modem technique, or an optical scanning technique. With somewhat greater financial outlay, the subjective estimate of sleep can be replaced with a more accurate, objective sleep measure derived from a wrist-worn actigraph (about \$2,000 per actigraph). Using actigraphic data, time periods when individuals

are awake/active can be differentiated from those when they are asleep/physically inactive (Brooks, Shergold, Angus, Heslegrave, & Redmond, 1988; Elsmore & Naitoh, 1993). Any of these methodologies would facilitate rapid accurate evaluation of sleep logistics in NSW exercises or operations.

CONCLUSION

Graphic analysis of sleep log/sleep questionnaire data revealed that Exercise 1 caused fragmented, but not shortened, sleep. Participants were prevented from obtaining the 7-8 hours of continuous nocturnal sleep required for optimum recuperation from daily fatigue; however, the demands of the mission did not cause accumulation of a sleep debt or a major shift in the work/rest schedule. All participants got some nocturnal sleep. Exercises with this sort of schedule should not impair cognitive performance unless they last for extended periods (more than 4 weeks). In contrast, for participants in Exercise 2, total sleep time was significantly shorter, and sleep was more fragmented and shifted. Morning sleep replaced nocturnal sleep, and the work period extended from the afternoon through the 0300-0600 time period. The stress inherent in a long work period was combined with the stress of working during the late night and early morning hours. Appropriate sleep management interventions in future similar exercises could decrease the risks of accidents or cognitive impairment efficiency and/or safety.

These two exercises demonstrate that NSW missions may involve schedules entailing varying risk of sleep deprivation related cognitive impairment. Further study of NSW work/rest schedules is needed for appropriate recommendations and guidelines to be developed. Likewise, studies of interventions such as melatonin, modafinil, sleep training tapes, and bright light under NSW relevant conditions could be conducted if the NSW community expresses a need for this. Such research could increase the methods and techniques available to promote sleep and/or alertness under operational work schedules.

REFERENCES

- Brooks, C. J., Shergold, D. J., Angus, R. G., Heslegrave, R. J., & Redmond, D. P. (1988). Actigraph measurements of work/sleep patterns during a Navy operation. *Journal of Royal Naval Medical Services*, 74, 153-164.
- Elsmore, T. F. & Naitoh, P. (1993). *Monitoring of activity with a wrist-worn actigraph: Effects of amplifier passband and threshold variations* (Technical Report No. 93-18). San Diego, CA: Naval Health Research Center.
- Lewis, H.E. & Masterson, J.P. (1957). Sleep and wakefulness in the Arctic. *Lancet*, June 22, 1261-1265.
- Mullington, J., Spielman, A., Wells, R. & Hoffman, R. (1988). Subjective estimation of nocturnal sleep length and stability of sleep patterns. A 42-night sleep log study. *Sleep Research*, 17, 342.
- Naitoh, P. (1982). Chronobiologic approach for optimizing human performance. In F. M. Brown & R. C. Graeber (Eds.), *Rhythmic aspects of behavior* (pp. 41-103). Hillsdale, NJ: Lawrence Erlbaum.
- Naitoh, P. & Kelly, T. L. (1992). *Sleep management user's guide for Special Operations Personnel* (Technical Report No. 92-28). San Diego, CA: Naval Health Research Center.
- Naitoh, P., Englund, C.E. & Ryman, D. H. (1986). *Sleep management in sustained operations: User's guide* (Technical Report No. 86-22). San Diego, CA: Naval Health Research Center.
- Naitoh, P., Banta, G., Kelly, T., Bower, J., & Burr, R. (1990). *Sleep logs: Measurement of individuals and operational efficiency* (Technical Report No. 90-29). San Diego, CA: Naval Health Research Center.
- Navy Personnel Research and Development Center (1975). *Investigation of the Navy workweek at sea*. (NPRDC Special Report 76-2 For Official Use Only).
- Nicholson, A.N. & Stone, B. M. (1982). *Sleep and wakefulness: Handbook for Flight Medical Officers* (AGARD Report AGARD-AG-270E). City, ST: Advisory Group for Aerospace Research & Development.
- Shiftwork Research Team (1991). *Standard Shiftwork Index*. Medical Research Council/Economic and Social Research Council, University of Sheffield, Sheffield, England.

APPENDIX A: SLEEP QUESTIONNAIRE

Today's Date _____

NAME _____ RANK/RATE _____ RATING _____
SEX _____ SOC. SEC. # _____ - _____ - _____ DATE OF BIRTH _____ AGE _____
CURRENT DUTY STATION _____ DATE ASSIGNED _____

Instructions: Please fill in the blanks or circle the answer that best applies to you.
The completion of this questionnaire is voluntary. This information will be used for research only and will not become a part of your permanent service record. THE QUESTIONS BELOW ARE ABOUT YOUR USUAL SLEEP NOW.

For questions 1 and 2, please use 24-hour clock times:

- 1) At what clock time do you usually go to bed on workdays? _____
On days-off? _____
- 2) At what clock time do you usually wake up on workdays? _____
On days-off? _____
- 3) On workdays, do you go to bed and get up at fixed, regular times?
 1. Always or almost always
 2. Often
 3. Sometimes
 4. Never or almost never
- 4) How long does it usually take you to fall asleep after lights-out?
_____ Hours _____ Minutes
- 5) Do you ever have trouble falling asleep?
 1. Never or almost never
 2. Sometimes
 3. Often
 4. Always or almost always
- 6) If you do have trouble falling asleep, how often does this happen?
 1. Less than once a year
 2. Less than once a month
 3. About once a month
 4. 1 or 2 times per week
 5. 3 or 4 times per week
 6. 5 or more times per week
 7. Does not apply to me
- 7) If you have trouble falling asleep, what is it that keeps you awake?
 1. Thoughts running through my mind
 2. Aches and pains
 3. Too much noise
 4. List any other _____
 5. Does not apply to me
- 8) If you have trouble falling asleep, do you:
 1. Just lie in bed
 2. Turn on the light and read
 3. Get up
 4. List any other _____
 5. Does not apply to me
- 9) Do you take anything to help you fall asleep?
 1. Never or almost never
 2. Sometimes
 3. Often
 4. Always or almost always
- 10) If you take something to help you fall asleep, what is it?
 1. Medicine prescribed by a doctor
 2. Non-prescribed medicine
 3. List any other _____
 4. Does not apply to me

- 11) How many times during your usual sleep period do you wake up by yourself and then go back to sleep?
 1. Rarely or never
 2. 1 or 2 times
 3. 3 or 4 times
 4. 5 or 6 times
 5. 7 or 8 times
 6. 9 times or more
- 12) On how many days per week does this happen?
 1. 1 or 2 days per week
 2. 3 or 4 days per week
 3. 5 or more days per week
 4. Does not apply to me
- 13) When you wake up during your usual sleep period, how long does it usually take to go back to sleep?
 1. 10 minutes or less
 2. 10 to 20 minutes
 3. 20 to 30 minutes
 4. 30 minutes to an hour
 5. More than an hour
 6. Does not apply to me
- 14) Do you ever wake up too early and find you cannot go back to sleep?
 1. Never or almost never
 2. Sometimes
 3. Often
 4. Always or almost always
- 15) On how many days per week does this happen?
 1. 1 or 2 days per week
 2. 3 or 4 days per week
 3. 5 or more days per week
 4. Does not apply to me
- 16) How often do you take naps?
 1. Rarely or never
 2. Less than once a month
 3. About once a month
 4. 1 or 2 times per week
 5. 3 or 4 times per week
 6. 5 or more times per week
 7. More than once a day
- 17) How long do you usually sleep during your naps?
 1. Between 10 and 30 minutes
 2. Between 30 and 60 minutes
 3. Between 1 and 2 hours
 4. More than 2 hours
 5. Does not apply to me
- 18) Do you have disturbing dreams or nightmares?
 1. Never or almost never
 2. Sometimes
 3. Often
 4. Always or almost always
- 19) Overall, what kind of sleeper are you?
 1. Very good
 2. Good
 3. Average
 4. Poor
 5. Very poor
- 20) If you are a poor or very poor sleeper, is this because you (mark most important)
 1. Have trouble falling asleep
 2. Wake up and have trouble going back to sleep
 3. Have disturbing dreams or nightmares
 4. Are awakened frequently by noise
 5. Wake up too early (early morning awakening)
 6. Wake up tired
 7. Other _____
 8. Does not apply to me
- 21) If you are a poor or very poor sleeper, how long have you had a sleep problem?
 1. 1 to 6 months
 2. 6 months to 1 year
 3. 1 to 2 years
 4. 3 to 5 years
 5. 5 to 10 years
 6. As long as I can remember
 7. Does not apply to me
- 22) Were (or are) any members of your family poor sleepers, that is, have sleep problems?
 Yes _____ 1 No _____ 2
- 23) If yes, which family member, or members if more than one?
 1. Father
 2. Mother
 3. Brother
 4. Sister
 5. Does not apply to me
- 24) Do you usually feel well-rested after you wake up and first get out of bed?
 1. Always or almost always
 2. Often
 3. Sometimes
 4. Never or almost never

- 25) Which choice below best describes how you usually feel for the first 2 or 3 hours after you wake up from your normal sleep period on workdays?
1. Alert, wide awake
 2. High level, but not at peak
 3. Awake, but relaxed
 4. A little foggy, let down
 5. Slowed down, sleepy
 6. Fighting sleep
 7. Almost asleep
- 26) Which choice below best describes how you usually feel in the afternoon, between 1500 and 1700?
1. Alert, wide awake
 2. High level, but not at peak
 3. Awake, but relaxed
 4. A little foggy, let down
 5. Slowed down, sleepy
 6. Fighting sleep
 7. Almost asleep
- 27) Do you ever fall asleep even though you are trying hard to stay awake?
1. Never or almost never
 2. Sometimes
 3. Often
 4. Always or almost always
- 28) Are you easily awakened by noises?
1. Never or almost never
 2. Sometimes
 3. Often
 4. Always or almost always
- 29) How much do you smoke each day?
1. None
 2. Less than 1 pack
 3. 1 pack
 4. 2 packs
 5. More than 2 packs per day
- 30) How much coffee, tea, or coke do you drink per day? (if coke, circle coke)
1. None
 2. 1 cup or 1 coke
 3. 2 to 3 cups or 2 to 3 cokes
 4. 3 to 5 cups or 3 to 5 cokes
 5. More than 5 cups or 5 cokes

APPENDIX B: SLEEP LOG

NAME	DATE	TIME	DUTY
------	------	------	------

1. On the chart below draw a horizontal line through the squares corresponding to the half hour periods during which you were asleep during the last 24 hours. Put an X in the square corresponding to any half hour period during which you recall waking up for 15 to 30 minutes.

DAYTIME															
0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000				
NIGHTTIME															
2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800				

2. How much trouble did you have going to sleep last night?		Time to fall asleep	3. How many times do you recall waking up last night?
<input type="checkbox"/> NONE	<input type="checkbox"/> SLIGHT	<input type="checkbox"/> MODERATE	<input type="checkbox"/> CONSIDERABLE
		_____ MINUTES	
4. How rested do you feel?		5. Do you feel that you could have used more sleep?	
<input type="checkbox"/> WELL RESTED	<input type="checkbox"/> MODERATELY RESTED	<input type="checkbox"/> SLIGHTLY RESTED	<input type="checkbox"/> NOT AT ALL
		<input type="checkbox"/> YES	<input type="checkbox"/> NO
6. Today's Mood		Number of dreams recalled	7. Hours of work in last 24 hours?
<input type="checkbox"/> VERY POOR	<input type="checkbox"/> POOR	<input type="checkbox"/> AVERAGE	<input type="checkbox"/> GOOD
		_____	_____

REMARKS (Note especially reasons for loss of sleep, such as duty, noise, cold, personal, etc.)

SLEEP LOG 11ND-COM-6520 1 (REV. 8-72)

NMNPUR (11-70)

Choose one of the seven statements below which best describes your present feelings. How you feel right now.

- (1) Feeling active and vital; alert; wide awake.
- (2) Functioning at a high level, but not at peak; able to concentrate.
- (3) Relaxed; awake, responsive, but not at full alertness.
- (4) A little foggy; let down; not at peak.
- (5) Foggy; slowed down; beginning to lose interest in remaining awake.
- (6) Sleepy; woozy; prefer to be lying down; fighting sleep.
- (7) Almost in reverie; sleep onset soon; losing struggle to remain awake.

APPENDIX C: ANALYSIS OF SLEEP SURVEY DATA

BRIEF EXPLANATION ON HOW TO ANALYZE SLEEP SURVEY DATA

PURPOSES OF SLEEP LOG ANALYSIS

Sleep logs are used to measure daily fluctuations in quality and quantity of sleep from a large number of people during a field exercise/operation. Together with a sleep questionnaire that reflects habitual sleep pattern, sleep logs will be able to quantify an amount of "sleep debt" accumulated during a field operation. Sleep questionnaire and logs create the basic data on which *Sleep Management* is based.

INFORMATION EXTRACTED FROM SLEEP QUESTIONNAIRES

1. Total sleep time per 24 hours on weekdays
2. Total sleep time per 24 hours during the weekend

INFORMATION EXTRACTED FROM SLEEP LOG CARDS

1. Number of sleep log cards submitted by a person
2. Dates when sleep log cards are completed
3. Mean and standard deviation (SD) of the question 2 "How much trouble going to sleep." The scoring key is:

NONE = 1

SLIGHT = 2

MODERATE = 3

CONSIDERABLE = 4

4. Mean and standard deviation of the question, "Time to fall asleep."
5. Mean and standard deviation of question 3, "How many times recall waking up?"
6. Mean and standard deviation of question 4, "How rested do you feel?" The scoring key is:

WELL RESTED = 1

MODERATELY RESTED = 2

SLIGHTLY RESTED = 3

NOT AT ALL = 4

7. Mean and standard deviation of question 5, "Could have used more sleep." The scoring key is:

YES = 1

NO = 2

8. Mean and standard deviation of question 6, "How is your mood today?" The scoring key is:

VERY POOR = 1

POOR = 2

AVERAGE = 3

GOOD = 4

9. Mean and standard deviation of the question, "Number of dreams you recall."
10. Mean and standard deviation of question 7, "How many hours did you work in the last 24 hours?"

HOW TO CREATE GROUP SUMMARY OF SLEEP LOG DATA

1. Determine how many individuals and how many groups completed sleep logs.
2. Determine if the sleep log data are to be summarized by:
 - 2.1 groups (e.g., a sleep log summary for a group of the boiler technicians, and separately for the Machinist's Mate), If there are 10 or more per group and groups have significantly different sleep patterns, then groups should be separated. If less than 5 in a group, only separate if they have very different sleep patterns.
 - 2.2 days (e.g., a 1-10 day transit phase in an 11-15 in-port phase, etc.), or
 - 2.3 both groups by days, or
 - 2.4 just one global group.
3. Obtain appropriate summary statistics of all the above sleep log measures for each specified group.

ANALYSIS OF DATA ENTRIES IN RESPONSE TO QUESTION ONE OF SLEEP LOGS

The preparation consists of two parts:

1. keyboard entries of data to a computer for statistical analyses, and
2. keyboard entries of data to a PC in order to create plots.

The following plots can be generated:

 - 2.1 sleep episode plot;
 - 2.2 sleep fraction;
 - 2.3 inter-sleep interval plot;
 - 2.4 durations of uninterrupted sleep plot.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE NOVEMBER 1994	3. REPORT TYPE AND DATE COVERED Final;	
4. TITLE AND SUBTITLE Sleep During SEAL Delivery Vehicle (SDV)/Dry Dock Shelter Exercises Analyzed by a Graphic Approach		5. FUNDING NUMBERS Program Element: 61153N MR04 Work Unit Number: 101.003 6410 and 62233N MM33P30.02-6005	
6. AUTHOR(S) Naitoh, P., Kelly, T., Hunt, P., Goforth, H. W. Jr.		8. PERFORMING ORGANIZATION Report No. 94-30	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Health Research Center P. O. Box 85122 San Diego, CA 92186-5122		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Medical Research and Development Command National Naval Medical Center Building 1, Tower 2 Bethesda, MD 20889-5044			
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Paper-and-pencil sleep logs and sleep questionnaires were used in sleep surveys of two SDV/DDS exercises. The purpose of the sleep surveys was to evaluate work/rest-sleep schedules during naval operational exercises to optimize sleep management. In Exercise 1, a group of 17 SEALs volunteered to participate in the sleep survey, and in Exercise 2, 18 SEALs participated. Graphical analytic procedures have been developed to extract information rapidly from sleep logs and sleep questionnaires as to debilitating effects of naval exercises on sleep. These two exercises were similar in mission duration and objectives, but the graphic analysis showed that only during Exercise 2 was sleep disturbed sufficiently to cause a "sleep debt" and increased fatigue. This analysis suggests that the application of sleep management principles to planning future missions with similar profiles could decrease unnecessary fatigue and sleepiness, improving individual/crew performance efficiency and operational safety. Use of sleep surveys during any type of naval exercise is recommended to evaluate and minimize work/rest-sleep disruption.			
14. SUBJECT TERMS Sleep; SEALs; submarine; work-rest schedule		15. NUMBER OF PAGES 26	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited